Recent Quarkonia Results from the PHENIX Experiment at RHIC

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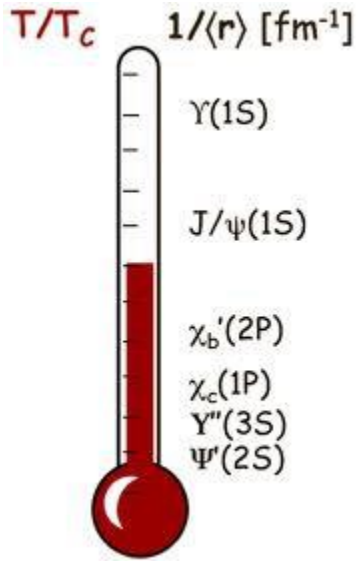
Quarkonia as a Probe of Deconfined Matter

Dissociation of quarkonium by color screening in deconfined matter is predicted to be different for different states.
At T/T_C ~2.5 only J/ψ and Υ will survive.



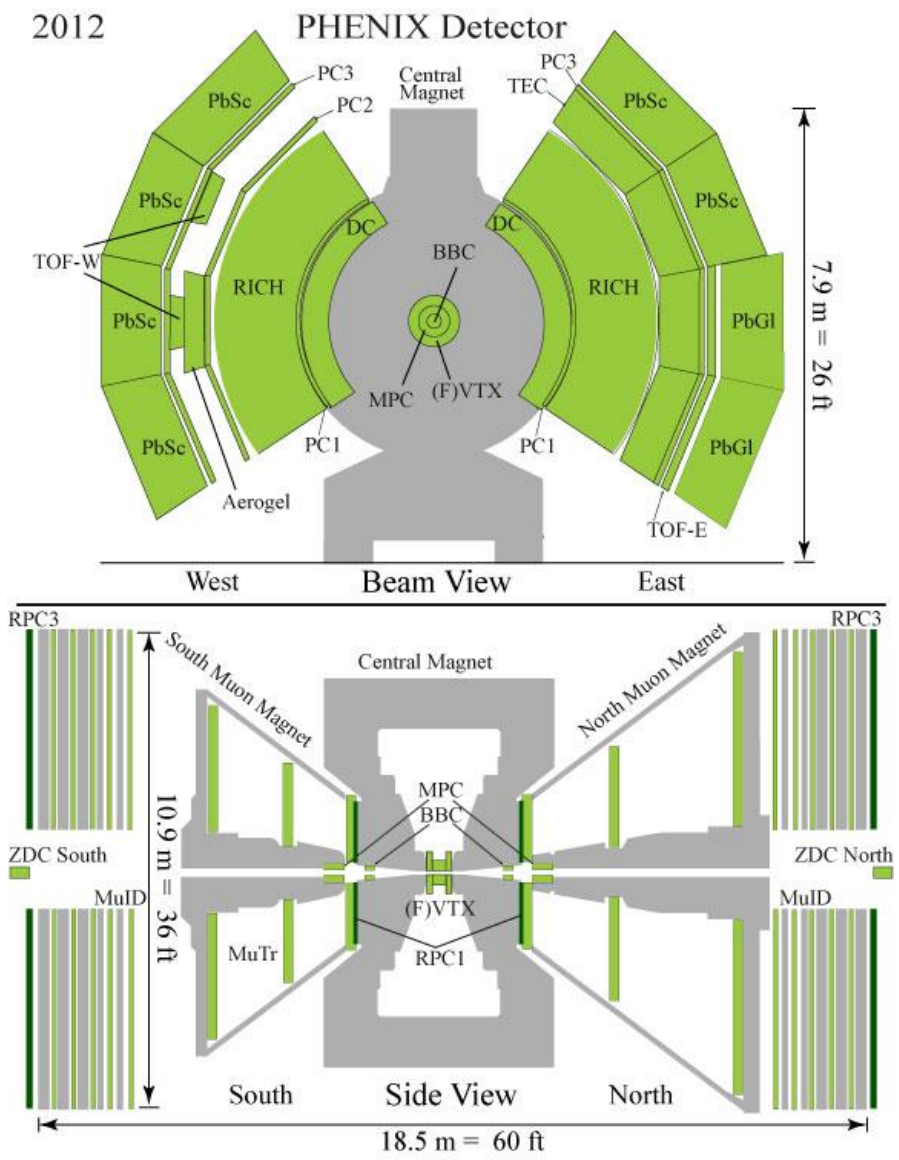
Excellent tool to probe QGP….

…but only if we know all he references.

Many competing processes in AA collisions:
cold nuclear matter effects, color screening, initial state effects, regeneration, feed-down…

… need measurements for different energies, colliding species, quarkonium states, p_T and rapidity dependence…

The PHENIX Experiment



Quarkonium states are measured via di-lepton decays

Central Arms (electrons)

$|\eta| < 0.35 \quad \Delta\phi = 2 \times \pi/2$

$P > 0.2$ *GeV*

Muon Arms

$1.2 < |\eta| < 2.2 \quad \Delta\phi = 2\pi$

$P > 2$ *GeV*

Lots of Data taken by PHENIX

PHENIX measured J/ψ, ψ', Υ, χ_C at mid-rapidity, J/ψ, ψ' and Υ at forward/backward rapidity, from p+p through d+Au to U+U at $\sqrt{s}$ from 39GeV to 200GeV.

Most recent results:

J/ψ in U+U allows to extend system size study.

J/ψ in Cu+Au asymmetric collisions: is R_{AA} also asymmetric?

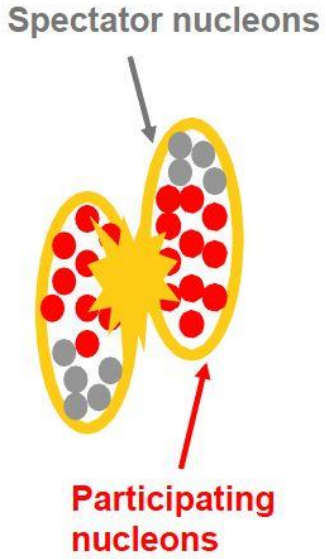
ψ' in d+Au – stronger than J/ψ suppression observed.

Υ in p+p and Au+Au at mid-rapidity and in d+Au at forward rapidity.
test bottonium suppression – extending QGP thermometer, no coalescence expected.

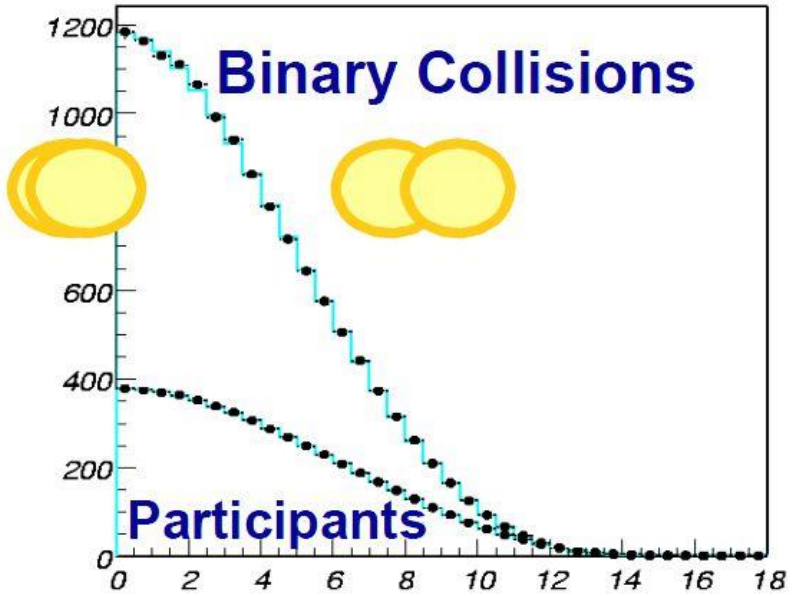
Nuclear Modification Factor R_{AA}

$$R_{AA} = \frac{dN_{AA}^{J/\psi}/dy}{N_{coll}\, dN_{pp}^{J/\psi}/dy}$$

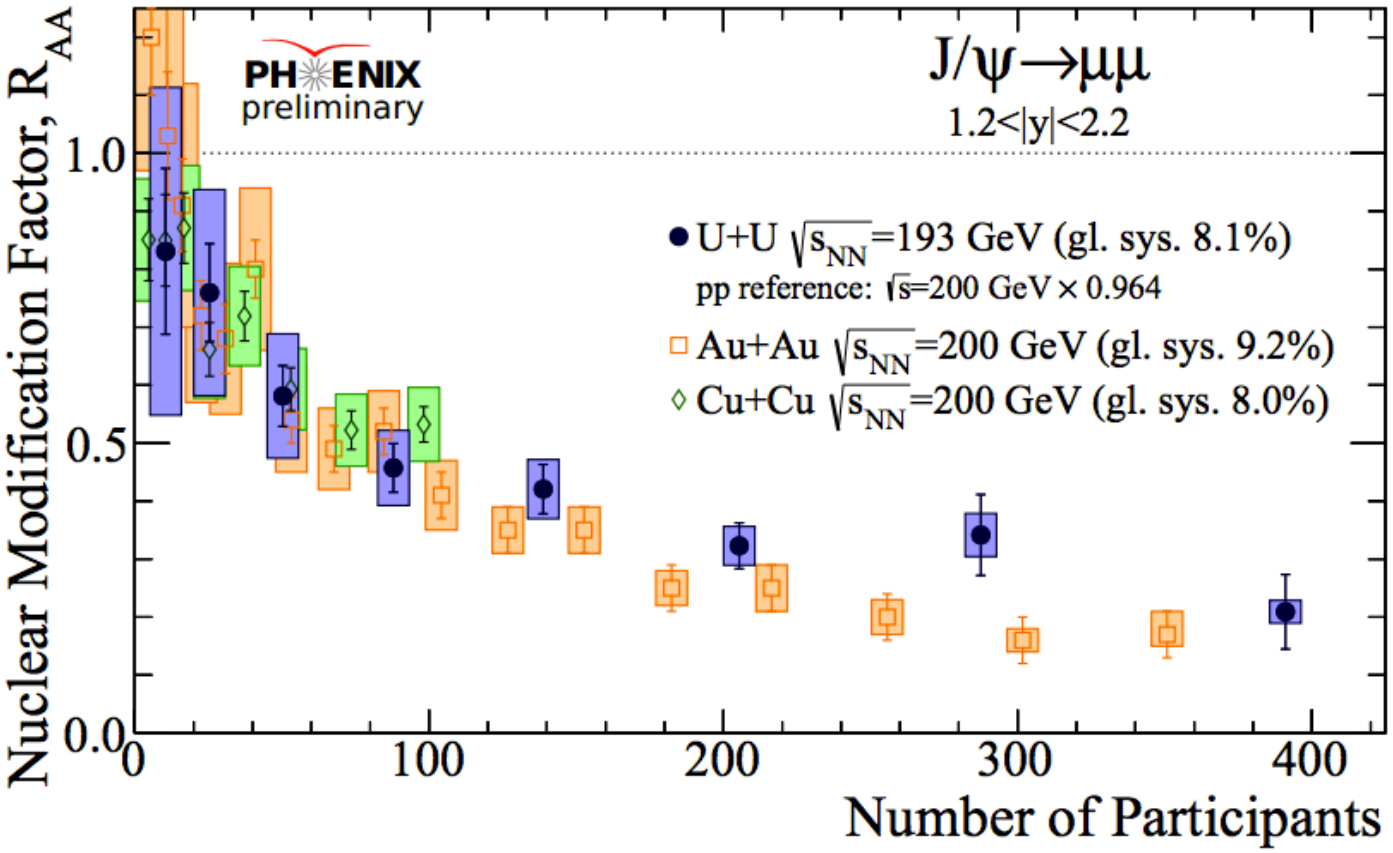
Yield in nucleus-nucleus collisions divided by p+p yields and scaled by the appropriate number of binary collisions N_{COLL}, which is calculated using Glauber model.



Centrality of collision is described by number of participant nucleons N_{PART}



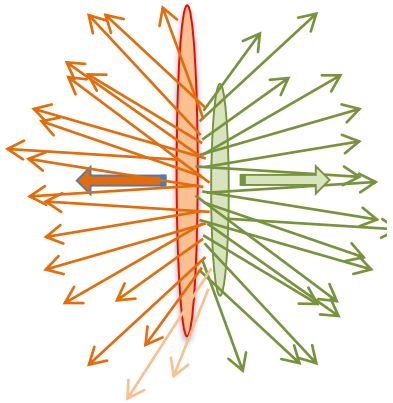
J/ψ in U+U: System Size Study

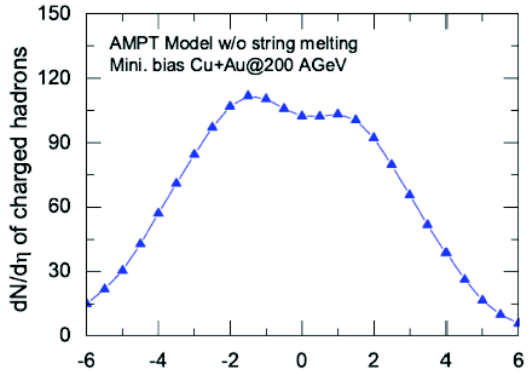


Qualitatively similar suppression from Cu+Cu to U+U.

Somewhat weaker suppression in central U+U collisions?
Higher coalescence?
(PRC 84, 054907, 2011)

J/ψ in Cu+Au: is R_{AA} also asymmetric?

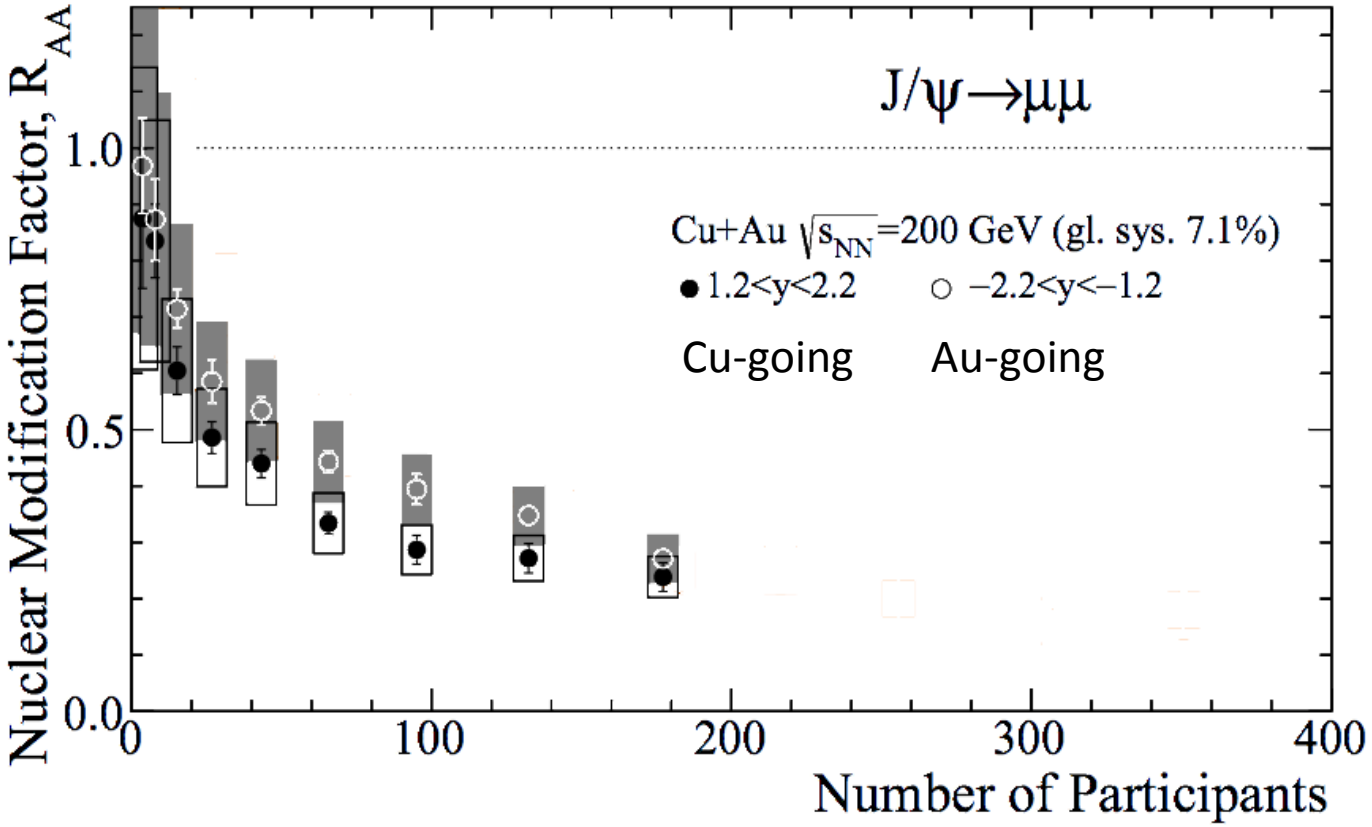




Initial asymmetry should result in asymmetric distribution of final particle density:

1) Asymmetric CNM effects.
2) HNM effects possibly asymmetric.

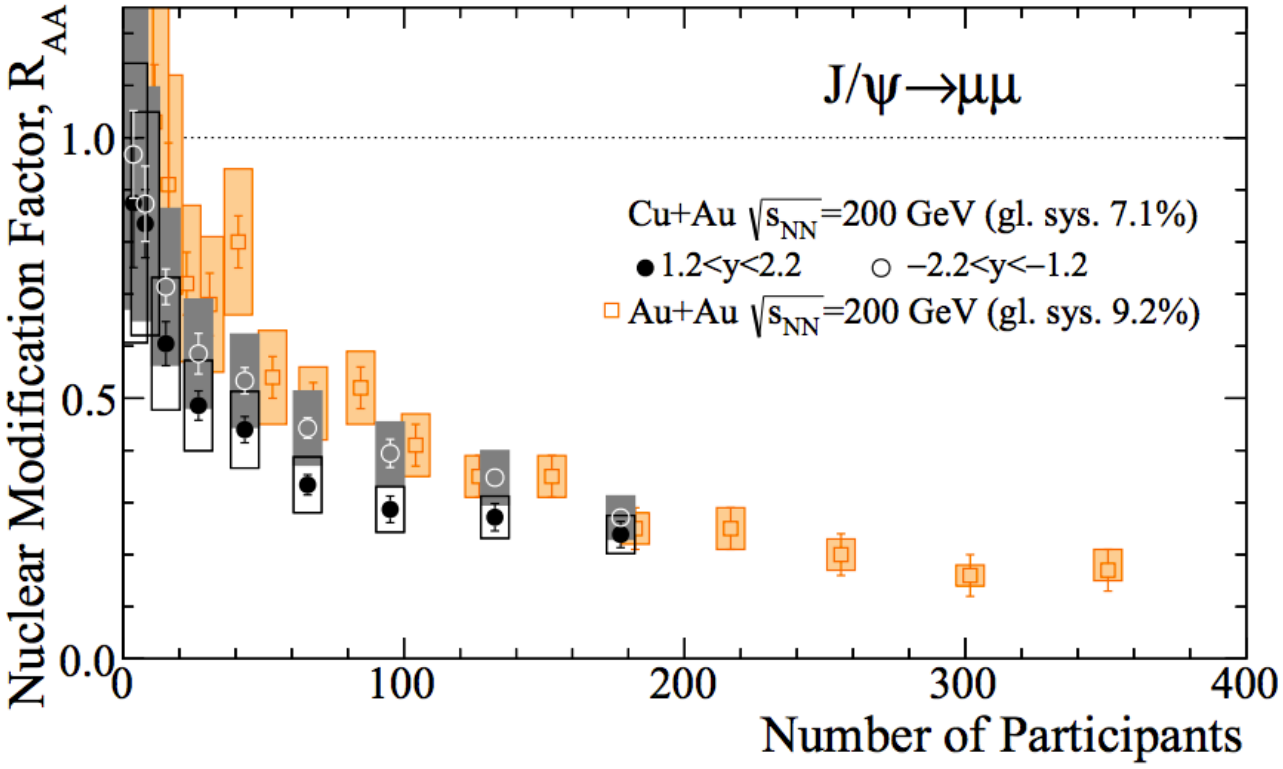
arXiv:1404.1873



The answer is yes, but not much:
Au-going R_{AA} is somewhat larger.

J/ψ in Cu+Au compared to Au+Au

arXiv:1404.1873

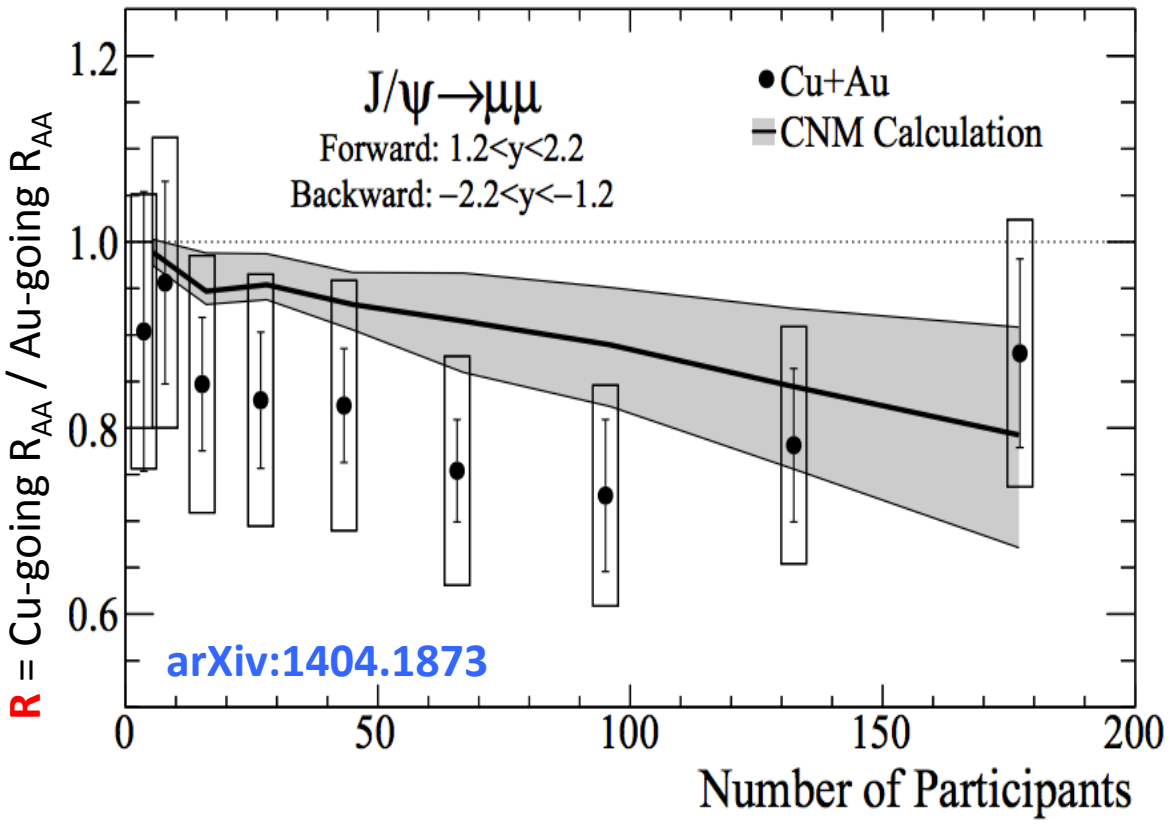


Similar, but somewhat smaller suppression in Cu+Au compared to Au+Au.

Cu-going R_{AA} more suppressed than Au-going.

J/ψ in Cu+Au: Cu-going/Au-going ratio

CNM = EPS09 + 4mb breakup (Phys. Rev. C84, 044911, 2011)

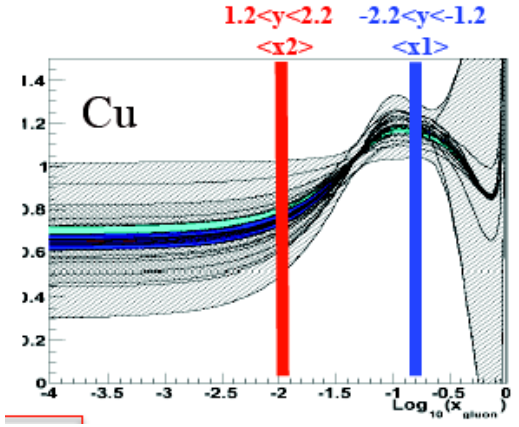


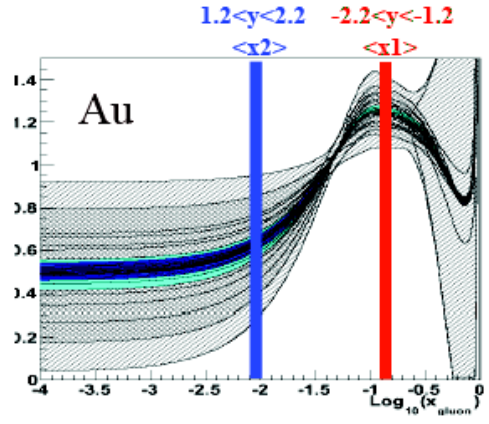
CNM effects:

Cu-going R_{AA} probes low x gluons in Au, J/ψ long proper crossing time.

Au-going R_{AA} probes low x in Cu, J/ψ short proper crossing time.

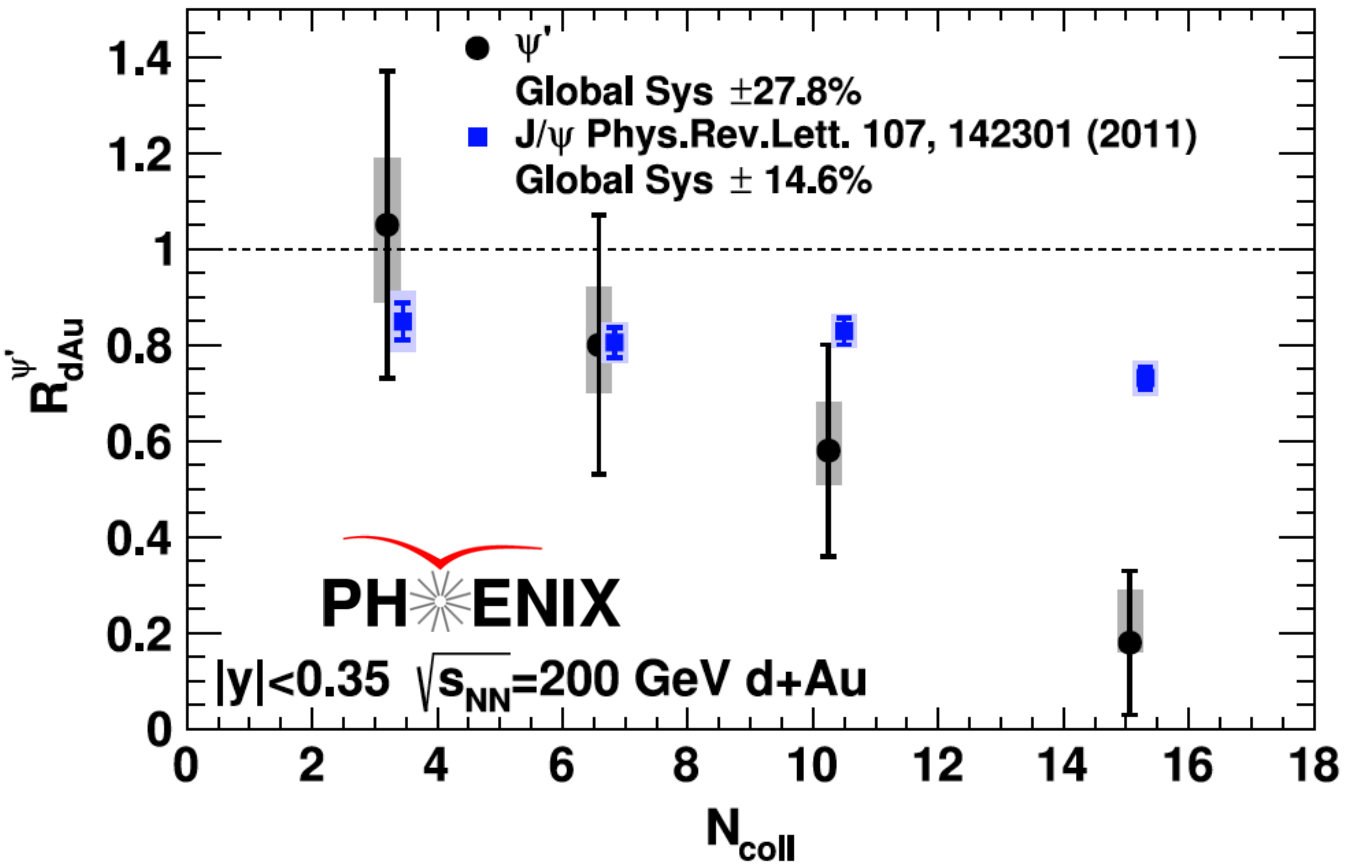
Observed **R** decreases with centrality.



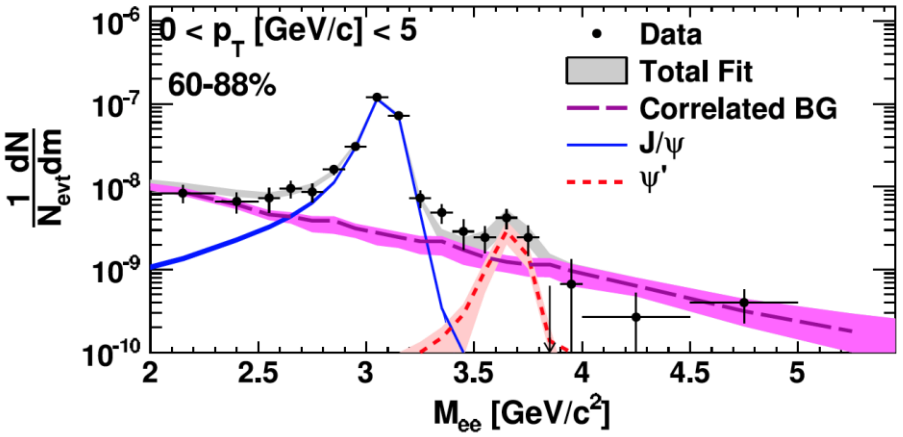


ψ’ in d+Au at mid-rapidity

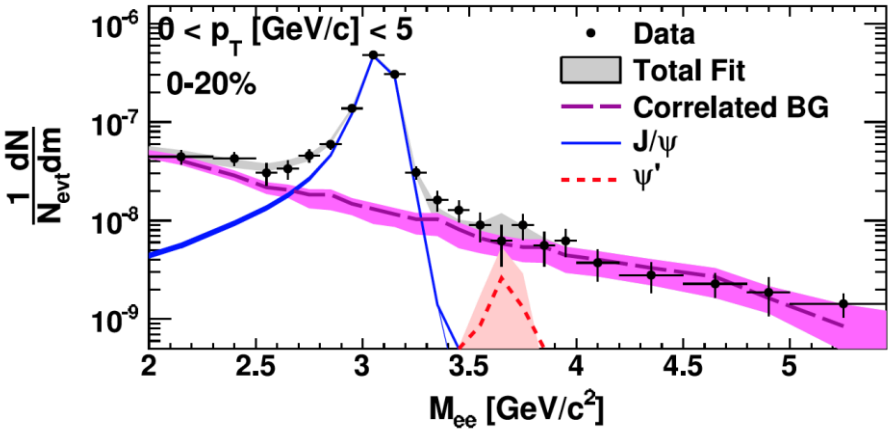
PRL 111, 202301 (2013)



Peripheral d+Au

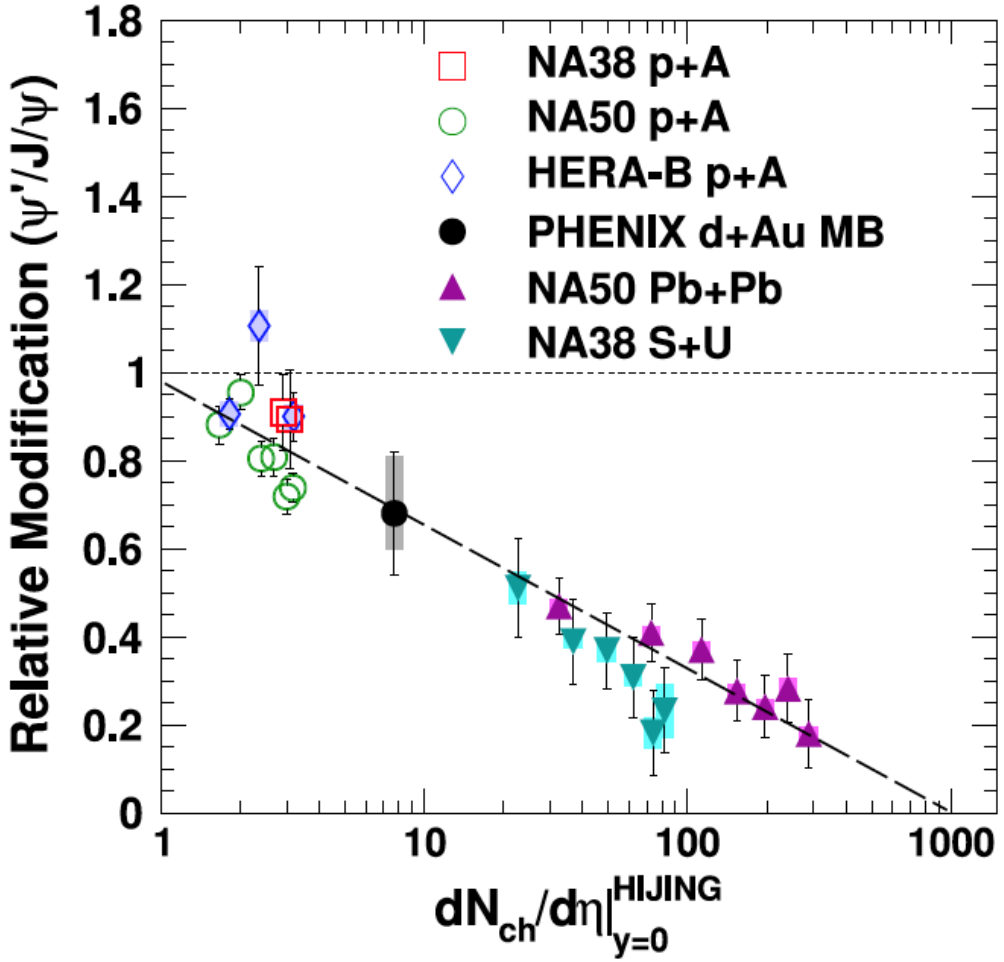


Central d+Au



ψ’ is ~3 times more suppressed in most central collisions than J/ψ. Very different trend with N_{COLL}.

Relative modification of ψ’



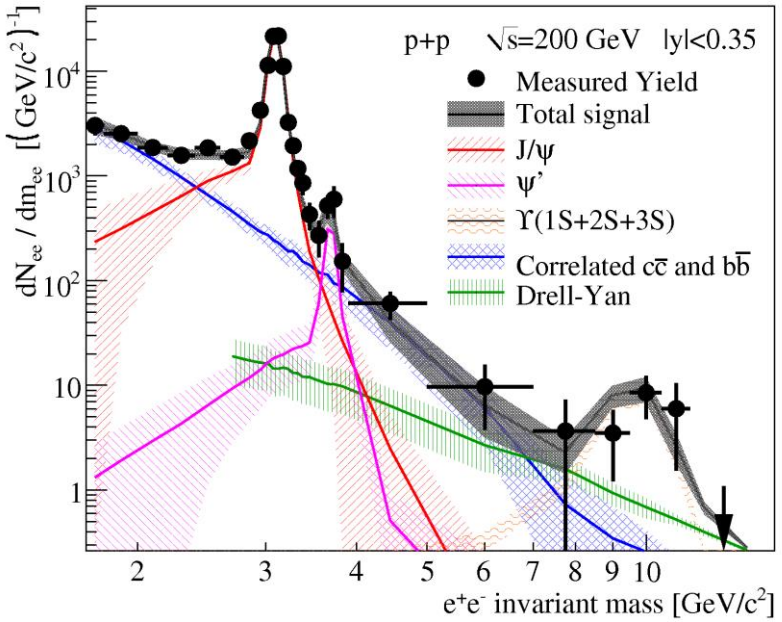
Relative modification in *all* systems follows common trend with increasing produced particle density.

Co-mover (or medium) density seems to be the relevant quantity.

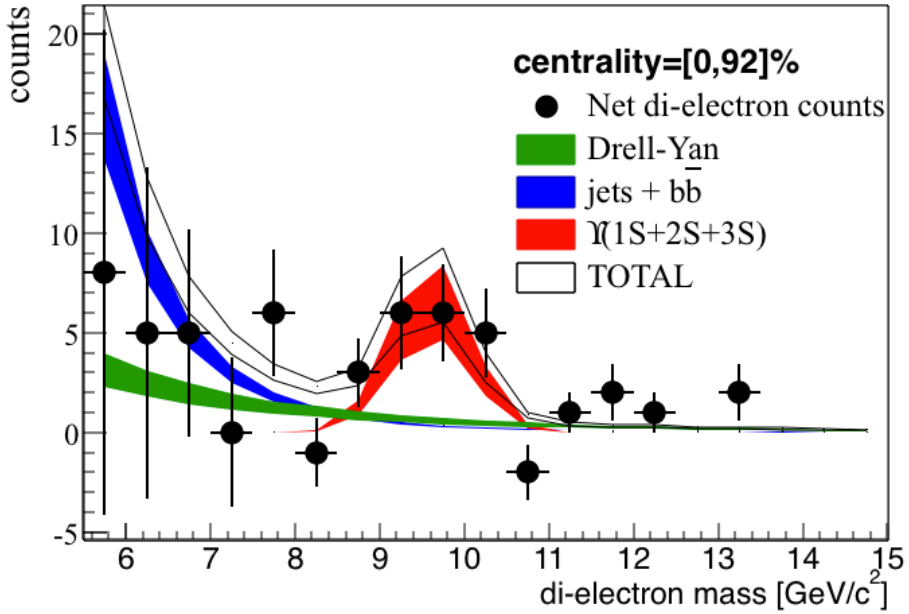
Upsilon measurement at mid-rapidity

arXiv:1404.2246

p+p



Au+Au

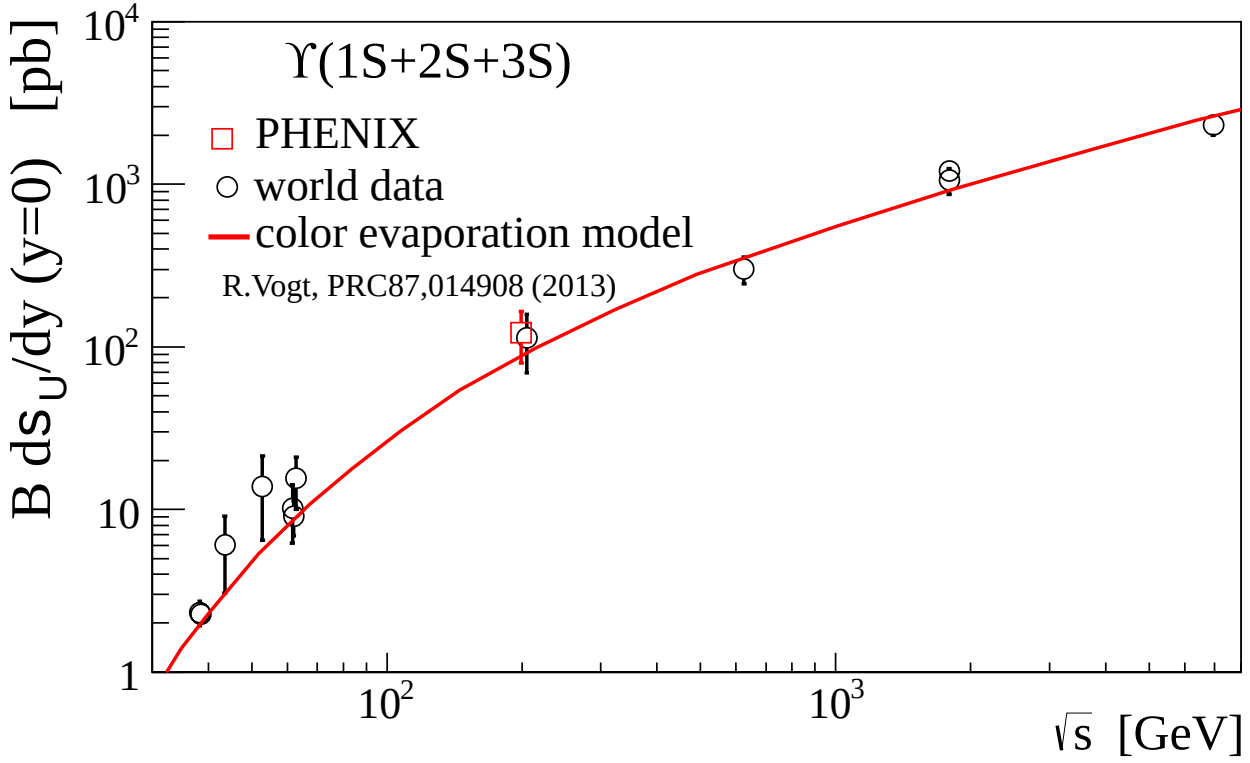


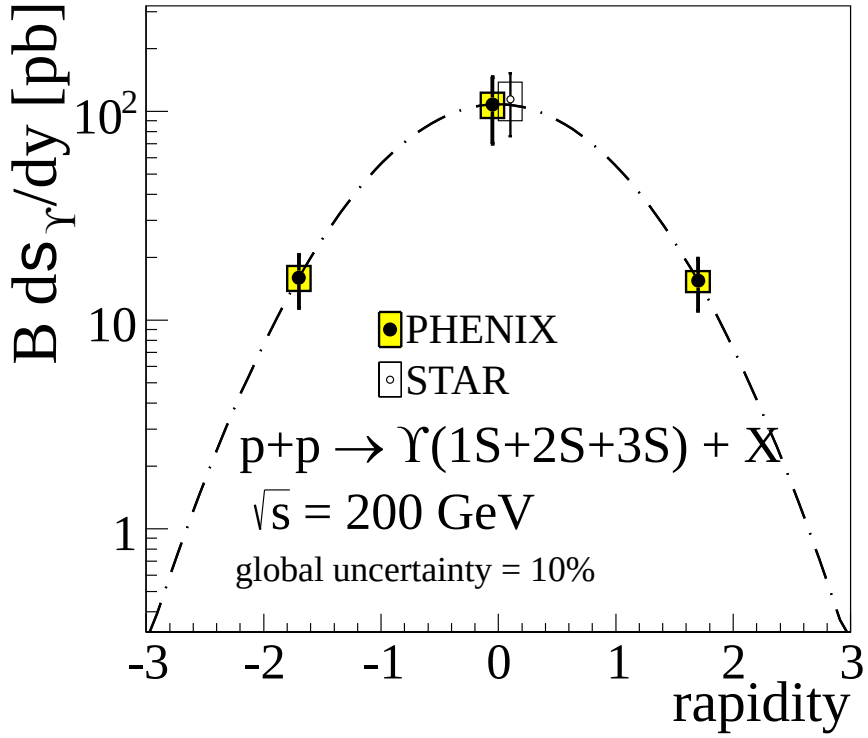
ϒ's are reconstructed in di-electron channel.

Clear combined (1S+2S+3S) ϒ peak observed both in p+p and Au+Au

Upsilons in p+p

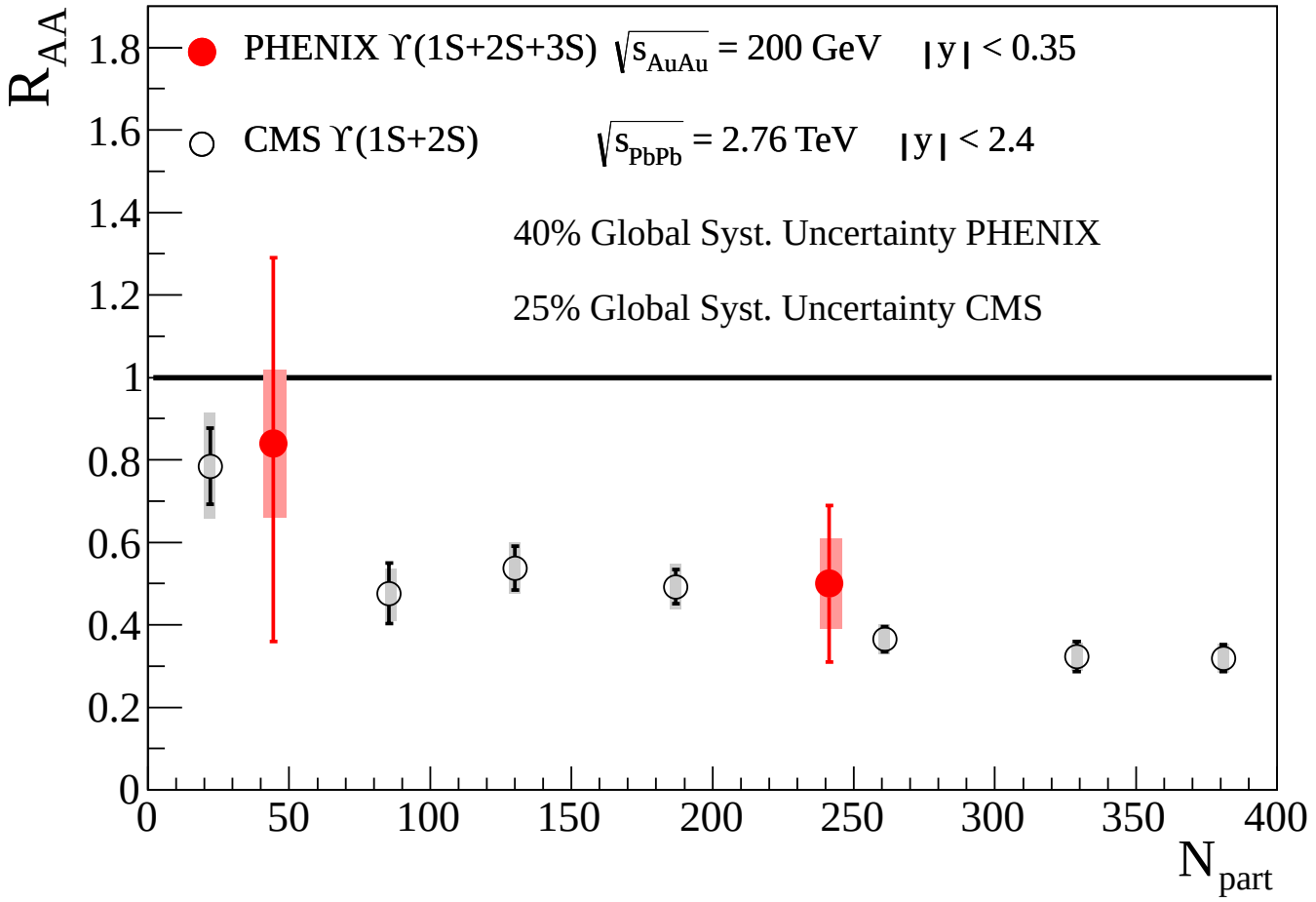
arXiv:1404.2246





Good baseline for studying Υ suppression in AA collisions.

Upsilon suppression in Au+Au at mid-rapidity

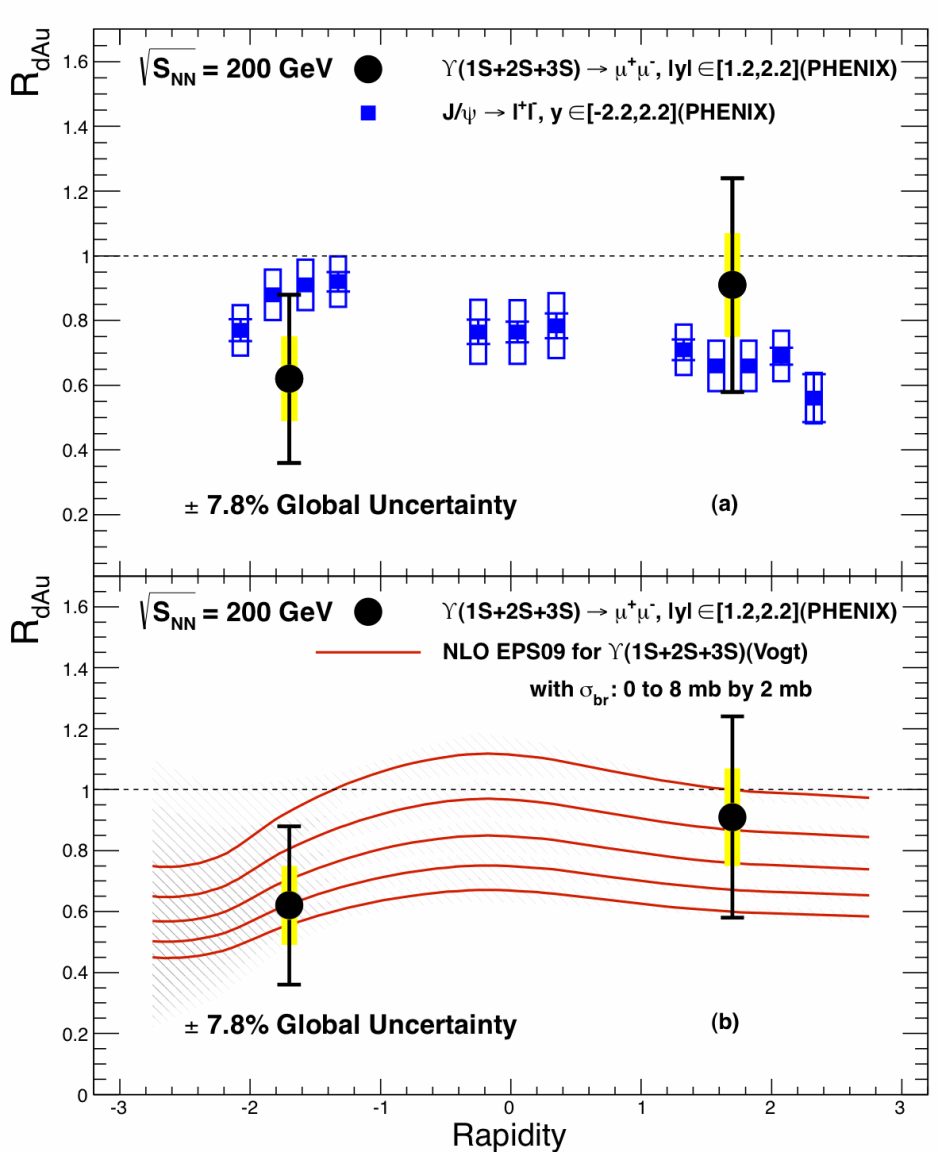


Expected maximum R_{AA}:
No 2S and 3S: 0.65 ± 0.11
No 2S, 3S and χ_B: 0.37 ± 0.09

Measured R_{AA} consistent with melting of 2S+3S.

Consistent with LHC results for the same N_{PART}.

Upsilons in d+Au at forward rapidity



Phys. Rev. C 87, 044909 (2013)

Suppression consistent with NLO+EPS09 (R. Vogt, Phys. Rev. C81, 044903, 2010) trend but unable to constrain breakup cross section due to large experimental uncertainties.

Conclusions

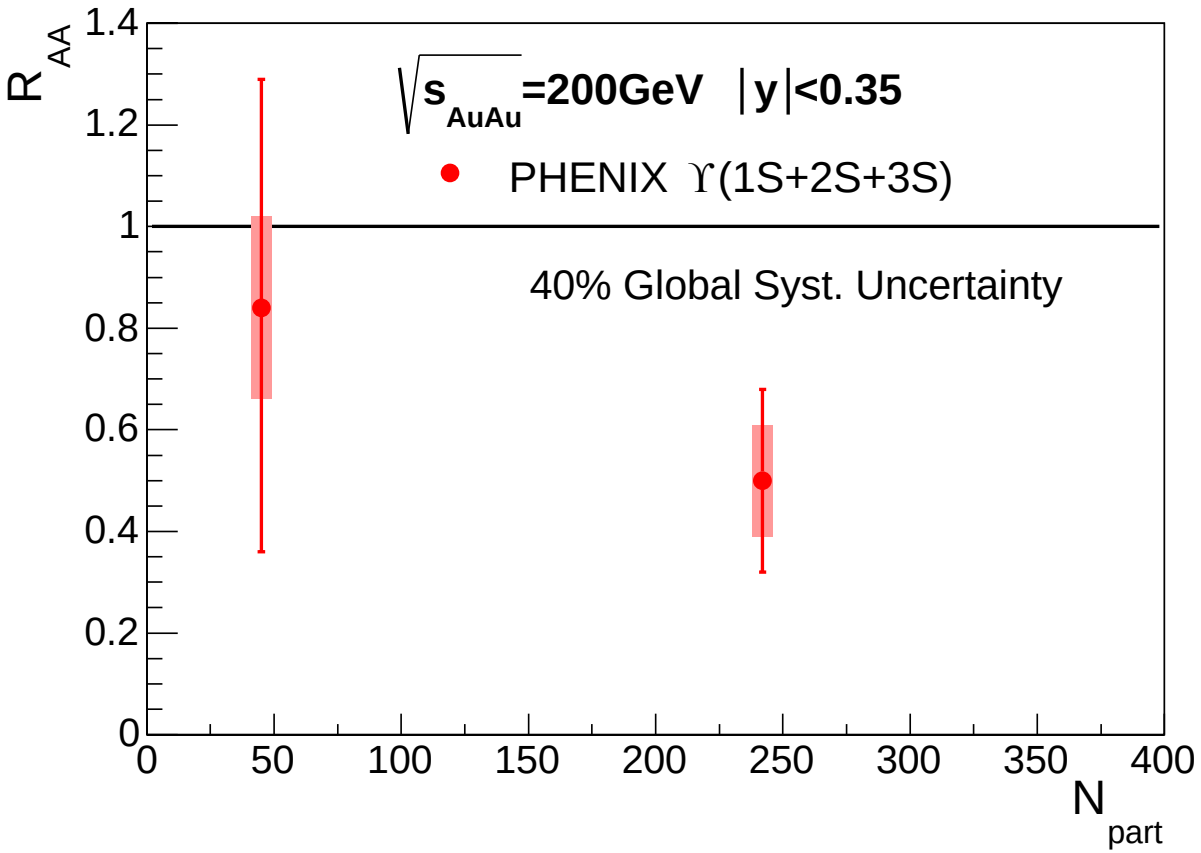
J/ψ R_{AA} is consistent between different colliding systems. ~20% differences despite expected variations in the CNM and QGP effects.

J/ψ R_{AA} in Cu+Au collisions asymmetric, with Au-going R_{AA} larger.

ψ' ~3 times more suppressed than J/ψ in most central d+Au collisions.

First Υ result from PHENIX shows suppression consistent with LHC results. Consistent with melting of Υ(2S) and Υ(3S).

Backup Slides


R AA
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
50
100
150
200
250
300
350
400
N part
√s AuAu =200GeV |y|<0.35
PHENIX ϒ(1S+2S+3S)
40% Global Syst. Uncertainty